



EFFECT OF CONCEPT MAPPING INSTRUCTIONAL STRATEGY ON STUDENTS ABILITY IN ORGANIC CHEMISTRY

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Abstract

The study investigated the effects of concept mapping instructional strategy on students' ability in organic chemistry. The study was carried out in Enugu State of Nigeria. Specifically the pretest posttest non-equivalent control group research design was used. The study employed a quasi experimental design. Three research questions and three null hypotheses guided the study. The experiment was done on the teaching of Chemistry to senior secondary school students two (SS2). A sample of 200 students (92 boys and 108 girls) selected randomly out of the population of 457 students in SS2 from four public secondary schools in Enugu State. Pre-test of Chemistry was given to both the groups and the results were recorded. One group was taken as a control group which was taught Chemistry by the teacher who used conventional approach of teaching while the other i.e the experimental group was taught by the teacher who used concept mapping teaching strategy. After one month's time of teaching, a post-test was conducted. Mean, standard deviation and Analysis of Co-Variance (ANCOVA) were used to analyze data. Results showed that concept mapping is an effective strategy for teaching and learning chemistry. The strategy is also capable of improving students' mastery of content at the higher-order levels of cognition. Based on the findings, the study recommended that concept mapping should be added to the teaching strategies of chemistry teachers at the secondary school level.

Keywords: Ability, Chemistry, Concept Mapping, Conventional Method, Organic Chemistry

Introduction

Science has permeated the life and daily activities of man to the extent that man's life can hardly be sustained without it. The advancement of science and technology is greatly governed by its application to societal needs and aspirations. Thus, the super powers, the developing and under-developed nations are classified based on their levels of scientific and technological advancement. This is with respect to their military might, economic power, industrial development and level of agricultural mechanization. The aforementioned indices of scientific and technological advancement require chemistry as



a core discipline. This may be among the reasons why the Federal Government of Nigeria in the NPE (2013, Revised) included chemistry as one of the science subjects offered in the senior secondary school.

Chemistry is one of the science subjects that deals with the study of matter, its changes, composition properties and uses (Ababio, 2004). Many of our day-to-activities revolve around chemistry. Chemistry is everywhere; chemistry is life; chemistry is the oracle of modern science. Chemistry teaching should involve creative ways of integrating the acquisition of self-reliant skills and the learning activities of the learner in the classroom (Igboegwu & Ikokwu, 2012). Also, chemistry is a critical determinant of the post secondary education and career options available to young people in the sciences (Nnaka, 2010). The importance of chemistry according to Ezeliora (2009) is the mirror of civilization in all the centuries of development and the most basic discipline for any person who would be truly educated in any science and in many other endeavours. In addition, Ezekannagha and Ifeakor (2005) pointed out that the functional role of chemistry in science and technology is so many that no area of science, technology and business enterprise escapes its application.

Despite the importance placed on chemistry, it is very disappointing to note that students' performance in the subject at both internal and external examinations has remained consistently poor (Udo & Eshiet, 2007 and Igboegwu, 2006). Reports show that mass failure in chemistry examination is real and the trend of students' performance has been on the decline (Udofia 2008 and Olayiwda, 2006). However, many variables that could be responsible for the poor performance of students in chemistry have been identified by Uduchukwu(2008). Such variables include government, curriculum, examination bodies, teachers, students, home and textbook. The government failed to recruit more qualified chemistry teachers with a teacher: student ratio of 1:80 to handle chemistry and this has failed to address the proper application of chemistry in everyday life (Okebukola, 2005). Moreover, some other variables that leads to poor performance include: poor primary school background in basic science, lack of interest on the part of students, lack of incentives for the teachers, incompetent teachers in primary schools, students' lack of interest, and large class syndrome (Akpan, 2008). Other variables according to Igboegwu, (2010) include: poor conditions of service for teachers, poorly equipped laboratories and teachers' late commencement of the practical aspect of chemistry.

Poor performance in chemistry which also emanates from anxiety and phobia has been observed by Aprebo (2002) to be an academic problem which has not yet been fully diagnosed for effective treatment. These anxiety and phobia are usually expressed on the faces of chemistry students in their classes because of a number of learning difficulties they are passing through. Aprebo further pointed out that the negative effect of the anxiety and phobia is spread to all other subjects that relate to chemistry. The West African Examinations Council (WAEC) Chief Examiner's Report (2010) suggested that students' performance in chemistry could be improved through meaningful and proper teaching.



According to the report, teachers should reduce the abstractness of chemistry, control the apathy and fear of the subject, and enhance students ability in Chemistry.

A chemistry teacher has both knowledge as well as skills in chemistry for the impartation of knowledge to the students. Organic and inorganic substances form major components of our chemical environment. Although organic substances such as sugar, starch, alcohol, resins, oil, indigo and others have been known from the earliest times, very little progress in their chemistry was made until about the beginning of the eighteenth century (Finar, 2008). The works of Lemery in 1676, and Lavoisier in 1784 led to the classification of substances that were produced by the living organisms as organic, and all those ones which were not prepared from living organisms as inorganic (Finar, 2008). Organic chemistry is the chemistry of the carbon compounds according to Finar (2008). The differences between the two classes of compounds have been disproved, and described organic chemistry as application of fundamental principles which consist of a large variety of methods and reactions. In recent times, these reactions have not been properly presented to the learners for proper understanding. As a result, there is still the need to find some effective ways of instruction like the concept mapping.

Concept maps can be utilized as teaching strategy for learning and teaching. Concept maps are tools that make ideas visual. They allow prior experience and understanding to be taken into consideration when building new concepts into the perceptual framework. By using concept maps, learners use their prior knowledge to understand the new concepts. It makes a link between unknown and known information that leads to deeper understanding (Novak, 2010). Concept mapping is a technique to let one person convey meaning and relationships to another person in a visual format, and concept maps have been shown to foster a joint understanding between two individuals viewing the same map. The concept map is believed to enhance recall and memory, aid in negotiation and balancing of conflicting needs, and create mutual understanding. A concept map is a graphical map visualizing the relationship among concepts. Concept mapping, emphasizing well-organized and structured knowledge, facilitate meaningful learning and creation of powerful knowledge frameworks. technique to let one person convey meaning and relationships to another person in a visual format, and concept maps have been shown to foster a joint understanding between two individuals viewing the same map. The concept map is believed to enhance recall and memory, aid in negotiation and balancing of conflicting needs, and create mutual understanding. Concept mapping is a problem-solving, activity oriented approaches to learning which offer learners the opportunity to participate and be actively involved in the whole process of teaching and learning. However, concept-mapping is a graphical or diagrammatically representation indicating interrelationship among concepts. Hence, concept-mapping is a teaching strategy that is activity oriented that enhances students abilities in Chemistry.

Focusing on the abilities of the learner, Magnuson (2007), contended that ability is the outcome of the extent to which a student, teacher or institution has achieved their educational goals. Victor (2019) reported that students' adjustment to academic



expectations has an effect on their academic ability. Victor added that, another very important enhancer of academic ability is the presence of physical activity. According to Victor, studies have shown that physical activity can increase neural activity in the brain and exercise specifically increases executive brain functions such as attention span and working memory. There arises the need for teaching methods that would motivate, arouse, sustain and increase the students ability in particular subjects. Therefore, ability as a factor in learning was among the central concepts in this study.

Chemistry is the mirror of civilization and a core subject in science and technology, and organic chemistry central to many industrial processes, learners are expected to acquire skills and attitudes that are needed to apply chemical concepts. Teaching method could be an important factor in propagating these skills. Therefore, there is the need to study the relative effectiveness of concept mapping as innovative method of teaching chemistry to enhance students ability in organic chemistry.

Chemistry may not be exciting to the students, and the end result leads to students' low achievement. The case of organic chemistry is particularly worrisome. Much as it is central to manufacturing and industrial processes for diverse products of human need. The attitude of teachers and students to organic chemistry is often unbecoming. Teachers are scared of venturing into it and students much more than teachers are scared of reading it. The structures and nomenclatures of organic compounds may not be the only reason. Indeed, it is a compelling necessity that effective strategies of enhancing achievement in chemistry be evolved. Some of such strategies may be the use of appropriate or innovative instructional strategy like concept mapping. Hence, the need to ascertain the relative effectiveness of concept mapping on students ability in organic chemistry in senior secondary schools in Enugu State.

Purpose of Study

The main purpose of this study was to determine the relative effectiveness of concept mapping and simulation game on the interest and achievement of students in organic chemistry. Specifically, the study was designed to investigate:

- i. Students' ability in Chemistry.
- ii. Ability of male and female students in Chemistry
- iii. Interaction effect of gender and instructional approach on students' ability in Chemistry

Research questions

The following research questions guided the study:

1. What is the effect of concept mapping approach on students' mean ability in Chemistry?
2. What is the effect of concept mapping on the mean ability of male and female students in Chemistry?



3. What is the interaction effect of teaching method and gender on Chemistry students' mean achievement?

Hypotheses

The following null hypotheses were formulated and tested at an alpha level of 0.05.

- HO₁: There is no significant difference in the mean achievement scores of students taught Chemistry with concept mapping approach and those taught Chemistry with conventional approach.
- HO₂: There is no significant difference in the mean achievement scores of male and female Chemistry students taught with concept mapping approach.
- HO₃: There is no significant interaction effect of teaching methods and gender on Chemistry students' achievement.

Research Method

This study adopted the quasi-experimental design. The specific design the researchers used for this study is a pre-test post-test non-equivalent control group design. The study was carried out in Enugu State of Nigeria. A total of two hundred senior secondary school students drawn from two intact classes of SS 2 were involved in the study. Four secondary schools were drawn from the secondary schools in Enugu State through simple random sampling technique. Because most of the schools in the area are coeducational, the researchers used four coeducational schools. The study was carried out with 200 students (92 boys and 108 girls) selected randomly out of the population of 457 students in SS2 from four public secondary schools in Enugu State. The instrument the researchers used for data collection is Chemistry Achievement Test (CAT). The instrument is a 30 item multiple choice test developed by the researcher from the content that was covered in the study. The items were drawn using a table of specification. The instrument covered the four topics in the chemistry concepts. The instrument was subjected to both face and content validation. The Kuder Richardson coefficient of internal consistency for the instrument is 0.89. Pre-test of Chemistry was given to both the groups and the results were recorded. One group was taken as a control group which was taught Chemistry by the teacher who used conventional method of teaching while the other i.e the experimental group was taught by the teacher who used concept mapping teaching strategy. After one month's time of teaching, a post-test was conducted.

Experimental Procedure

To control for possible pre-existing differences in overall ability between the treatment and control groups a pretest was administered to both groups before the commencement of the experiment in the respective schools. The treatment group was taught with concept mapping approach while the control group was taught with conventional approach using the same content outline for one month (four weeks).



Method of Data Analysis

Research questions were answered using mean and standard deviation while the analysis of Co-variance (ANCOVA.) was used to test the null hypotheses at 0.05 level of significance.

Results

Research Questions

Research Question 1: What is the effect of concept mapping on students' mean achievement in Chemistry?

Table 1: Mean Chemistry achievement scores of students taught Chemistry using the Concept Mapping and those taught with the conventional approach

Groups		Pre-test		Post-test		Mean Gain Scores	Mean Gain Difference
		N	Mean	SD	Mean	SD	
Experimental Group (Concept mapping approach)	Group	93	15.57	2.95	24.62	3.30	9.05
Control Group (conventional approach)	Group	107	14.76	3.46	19.63	3.75	4.87

Table 1 revealed that the adjusted mean achievement score for the experimental group was 15.57 with standard deviation of 2.95 at pre-test and 24.62 with standard deviation of 3.30 at post-test. The mean gain score of students exposed to concept mapping approach was 9.05. On the other hand, chemistry students who were exposed to conventional approach had mean achievement scores of 14.76 with standard deviation of 3.46 at pre-test and 19.63 with standard deviation of 3.75 at post-test. The mean gain scores of the chemistry students exposed to conventional approach was 4.87. The mean gain difference of 4.18 was recorded for the two groups in favour of chemistry students exposed to experimental group. However, the obtained standard deviation from students in both the experimental and control groups were relatively small; indicating that the variation from the mean was small. The two mean scores from the table tend to suggest that the students in the experimental group performed better academically than the students in the control group. This further suggested that concept mapping approach has positive effects on the students' academic achievement in chemistry.

Research Question Two: What is the effect of concept mapping on the mean achievement of male and female students in Chemistry?



Table 2: Mean Chemistry scores of males and females taught Chemistry using the concept mapping Approach.

Gender	Pre-test		Post-test		Mean Gain Scores	Mean Gain Difference
	N	Mean	SD	Mean	SD	
Male	92	15.92	3.53	22.67	4.50	6.75
Female	108	14.46	2.84	21.33	4.11	6.87

Table 2 indicated that at the pre-test, male chemistry students had mean achievement score of 15.92 with standard deviation of 3.53 while their female counterpart had mean achievement score of 14.46 with standard deviation of 2.84. At the post-test, male chemistry students had mean achievement score of 22.67 and standard deviation of 4.50 while female chemistry students had mean achievement score of 21.33 with standard deviation of 4.11. The mean gain score of the male chemistry students was 6.75 while the mean gain score of female chemistry students was 6.87. The results therefore, show that male chemistry students had a slight higher mean achievement score compared to their female counterpart. This can be seen from a very slight mean gain score difference of .12 in favour of the male students.

Research Question 3: What is the interaction effect of teaching method and gender on Chemistry students' mean achievement?

Table 3: Summary of interaction of gender and teaching method on students' mean achievement scores in Chemistry.

Groups	Gender	N	Mean	Std. Dev.
Experimental Group (Concept mapping approach)	Male	43	25.77	3.19
	Female	50	23.64	3.10
Control Group (conventional approach)	Male	49	19.96	3.65
	Female	58	19.34	3.84

As shown in Table 3 the adjusted mean scores of male and female chemistry students in the treatment group is higher than those of male and female chemistry students in the control group. The Table revealed that male chemistry students exposed to experimental group (Concept mapping approach) had a higher mean achievement score of 25.77 and standard deviation of 3.19 as against their male counterparts exposed to control group (conventional approach) that had mean achievement score of 19.96 with standard deviation of 3.65. On the other hand, female chemistry students exposed to experimental group (Concept mapping approach) had higher mean achievement score of 23.64 and standard deviation of 3.10 while their female counterparts in the control group (conventional



approach) had mean achievement score of 19.34 with standard deviation of 3.84. The results do not suggest ordinal interaction effect between methods of teaching and gender on students' achievement in Chemistry. This was because at all the levels of gender, the mean achievement scores were higher for students in the experimental group than those in the control group.

Hypotheses

Hypotheses One: There is no significant difference in the mean achievement scores of students taught Chemistry with concept mapping approach and those taught Chemistry with conventional approach.

Table 4: Summary of Analysis of Covariance (ANCOVA) of students' achievement in Chemistry when exposed to concept mapping approach and those not exposed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1530.194 ^a	4	382.548	33.826	.000	.410
Intercept	2538.190	1	2538.190	224.435	.000	.535
PretestAch	172.910	1	172.910	15.289	.000	.073
Method	1124.394	1	1124.394	99.422	.000	.338
Gender	41.044	1	41.044	3.629	.058	.018
Method * Gender	24.973	1	24.973	2.208	.139	.011
Error	2205.306	195	11.309			
Total	100096.000	200				
Corrected Total	3735.500	199				

Table 4 shows that teaching method is a significant factor on chemistry students' achievement; $F(1, 195) = 99.422$, $P = .000$. Thus, the null hypothesis of no significant difference was rejected. This is because the exact probability value of .000 is less than level of significance set at 0.05. Therefore, the researchers conclude that there is a significant difference in the mean achievement scores of Chemistry students exposed to concept mapping approach and those exposed to conventional approach.

Hypotheses Two: There is no significant difference in the mean achievement scores of male and female Chemistry students taught with concept mapping approach.

Result of the analysis in Table 4 was also used to test hypothesis two. The Table shows that gender is not a significant factor on Chemistry students' achievement; $F(1, 195) = 3.629$, $P = .058$. Therefore, the null hypothesis of no significant difference was accepted since the exact probability level of .058 is greater than level of significance set at 0.05. The researchers therefore, conclude that there is no significant difference in the mean achievement scores of male and female Chemistry students.



Hypothesis Three: There is no significant interaction between gender and instructional approach on students' mean achievement in Chemistry.

The result of the analysis in Table 4 was also used to test hypothesis three. The Table shows that the exact probability value of .139 associated with teaching methods and gender is greater than 0.05 level of significance; ($F(1, 195) = 2.208, P = .139$). Thus, the null hypothesis of no significant interaction effect of teaching methods and gender on chemistry students' mean achievement scores was upheld. The researchers therefore, conclude that the interaction effect of teaching methods and gender on Chemistry students' achievement is not significant.

Summary of Results

The results of data analysis presented above reveal that:

- i. The concept mapping approach is superior to the conventional approach in fostering chemistry students' achievement
- ii. There is no significant difference in the mean achievement scores of both male and female chemistry students taught Chemistry using the concept mapping approach.
- iii. There is no significant interaction effect of teaching methods and gender on Chemistry students' achievement.

Discussion of Results

The results of this study revealed that the students taught Chemistry with concept mapping approach performed significantly better than the students taught with conventional approach. In other words, the difference between the adjusted mean achievement of the experimental group was significant in favour of the experimental group. This implies that concept mapping approach has a positive effect on the Chemistry students' achievement. This finding is in agreement with the works of Ibiene (2009), which revealed that instructional method helps in imparting knowledge, skills, abilities and attitudes expertly to facilitate students achievement. This is also in line with the result of Onyeabor (2019), who in conclusion said that the process of drawing a concept map by students makes the task of revision more effective and simply and significantly makes learning more meaningful and consequently facilitates students' achievement in the subject. This result is equally in line with the result of Ogonnaya, Okafor, Abonyi & Ugama (2016), which revealed that concept mapping produced significant students' achievement in basic sciences. Also, Ryder (2004), observed that concept mapping attracts students' attention, motivate them, reduce anxiety and facilitates recall of information and hence, enhances their achievement. Moreover, Novak (1991), find out that the use of concept mapping in teaching and learning process provides concrete basis of conceptual thinking, offer a variety of experience, reduce meaningless word responses and makes learning more permanent and consequently, enhance students achievement.



From the results obtained and tested based on research question 2 and hypothesis 2, it is evident that the mean achievement of male and female Chemistry students is not significant. This implies that the difference between the achievement of male and females chemistry students is not significant. This further shows that concept mapping produced the same effect on the mean achievement of the male and female students. This further shows that concept mapping produced the same effect on the mean achievement of the male and female students. The result of this study is contrary to the work of Olatoye and Afuwaye (2004), which revealed that there is gender difference in the achievement of students in science subjects. This study that provides gender disparity is against other studies which showed that concept mapping is not gender biased. This is due to the fact that concept mapping presents concepts from known to unknown, shows meaningful relationships between concepts and promotes creative thinking in both male and female students. Concept mapping takes care of individual differences in the students and as well reduce to the barest minimum the bore on the students when taught with conventional approach.

Going further, the findings of the study showed no significant interaction effect between teaching method and gender on Chemistry students achievement. This shows that the concept mapping influenced Chemistry students' achievement independent of gender and abilities. The result is supported by the work of Danmole and Adeoye (2004), which yielded a similar result. This also, agrees with the findings of Agboro (2015) and Ibiene (2009) who found that there was no significant difference when interaction effect of gender and instructional method was explored, showing that the males and females were affected positively by the method. However, the instructional method (concept mapping) seemed to have provided an environment free from stress and boredom in which male and female chemistry students have achieved some level of equilibrium.

Conclusion

The major results obtained from this study based on data analysis reveal that Concept mapping method of teaching is more effective than the conventional method in fostering achievement of students in chemistry. The difference between the mean achievement of students in the concept mapping group and conventional group is statistically significant, and in favour of the concept mapping group. The study further reveals that concept mapping has no differential impact on the achievement of male and female students in chemistry. In the same vein also there is no significant interaction between gender and instructional method on chemistry students' achievement.

Recommendations

Based on the findings of the study, the researchers recommends that:

1. Chemistry curriculum planners and developers should include concept mapping approach in the suggested teaching methods.



2. The method is found to enhance students' achievement scores, students should be properly trained to acquire the skills and encouraged to apply it in their learning.
3. Secondary school Chemistry teachers should be sensitized and trained by relevant agencies like STAN, and the Federal Ministry of Education (FME) on the use of innovative teaching methods like Concept Mapping through seminars and workshops.
4. Teachers should be encouraged to use Concept Mapping in classroom instructions by their supervisors.
5. There should be literatures on Concept Mapping available to schools. This will make teachers and students more informed on how to use Concept Mapping. Teachers Training Institutions should incorporate Concept Mapping approach into their teaching method courses so that pre-service chemistry teachers will be equipped with this innovative approach.

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